Final Technical Report

Project title: **Development of a Model for the Night Side Magnetopause Using Global Simulations**

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1 Progress Summary

During the investigation we have finalized the event studies that are necessary for the development of the magnetopause model and for the calibration of our simulation code.

1.1 The March 29, 1993 event

We have completed the study of the March 29, 1993 event. We used IMP-8 data as input for our model and compared the results with data from Geotail. On this day, IMP-8 monitored the solar wind at (33,-18,-11) R_E, upstream of earth. The solar wind velocity and density were fairly steady and the IMF predominantly northward, with a period of strong northward IMF from about 1200 UT to 2100 UT. Geotail was in the distant tail at (-134,7,-1) R_E in aberrated GSE coordinates. During much of the second half of the day, Geotail observed plasmas and fields that were neither typical for the tail nor for the magnetosheath. However, there were a number of fairly sharp discontinuities that indicate magnetopause crossings. The comparison of the Geotail data with our simulation results showed a good agreement. In particular, most of the major magnetopause crossings were reproduced by the simulation.

The simulation also showed why Geotail entered the magnetosheath several times although the spacecraft was nominally located well within the tail. Due to the anisotropic magnetic field pressure in the magnetosheath, the tail becomes confined to an elliptical cross section. The major axis always aligns with the ambient magnetosheath field direction in the Y - Z plane. Rotations of the IMF clock angle that propagate through the nightside magnetosheath cause the tail to twist back and forth, thereby causing Geotail to exit the tail. This time interval was of further interest, because at times the tail became twisted so strongly that the northern lobe appeared in the southern hemisphere and vice versa. This is an important finding with respect to our proposed tail model because it shows that a simple

tail geometry is often not applicable. This event study is now completed. The results were presented at several meetings [*Raeder et al.*, 1995a, b; *Raeder*, 1995b; *Raeder et al.*, 1996b; *Raeder*, 1997; *Raeder et al.*, 1997c], and two papers have been submitted for publication [*Raeder et al.*, 1998; *Ashour-Abdalla et al.*, 1998].

1.2 The July 7, 1993 event

During this event, which occurred between 1400 UT and 1800 UT on July 7, 1993, Geotail was in the distant tail near (-196,-11,8) R_E, and IMP-8 measured the IMF and solar wind plasma at (18,-27,15) R_E. During the time period of interest, the solar wind was fairly steady and the IMF predominantly northward, with some slow rotations in the east-west component. We found an excellent agreement between the simulation results and the Geotail observations, which provided the basis for further studying the event. The simulation showed that the combined action of magnetic reconnection and the slow rotation of the east-west component of the IMF caused a braiding of magnetic field lines about the tail axis that results in some unexpected topological features. In particular, tracing magnetic field lines from the simulation showed that Geotail was at times located on open field lines connected to the southern hemisphere, although the spacecraft position was about 8 R_E above the equatorial plane. Like for the March 29, 1993 event, the tail was of elliptical shape because of the strong northward IMF, which makes this event an ideal case to be used for our tail model. This event study is now completed. Results were presented at meetings [*Berchem et al.*, 1995d, e, a, b, c], and two publications have been accepted and are in press [*Berchem et al.*, 1998a, b].

1.3 The December 14, 1994 event

On this day, from 1200 to 1800 UT, Geotail was located in the middle tail at about (-46,-14,-6) R_E, while the Wind spacecraft monitored the solar wind upstream of the bow shock near (24,-38,0) R_E . Like the previous studies, we choose this event because the IMF was predominantly northward and geomagnetic activity was low. Our simulation results compare excellently with the Geotail observations, in particular a continuously small northward field in the tail and slow tailward flows. Although Geotail did not cross the magnetopause on this day, this simulation helps us to understand the processes in the quiet tail, and the results of this simulation will be used for our comprehensive tail model. Results of this simulation and the comparisons with Geotail data have been presented at meetings [*Raeder et al.*, 1995a; *Raeder*, 1995a, 1996; *Raeder et al.*, 1996b], and been published [*Raeder et al.*, 1997b].

1.4 Southward IMF events

We have also studied events in which the IMF is predominantly southward. The first of these events occurred on February 8/9, 1995. For this event we used Wind solar wind and IMF data and compared the results with Geotail data. The second event, also with Wind and Geotail data, occurred on December 13, 1994, and encompasses a series of substorms. The third event occurred on May 19/20, 1996. For the latter event we have Wind data available

to drive the model and IMP-8 data from the tail. All these events are characterized by high geomagnetic activity. We have carried out an analysis of these events and presented the results [*Raeder et al.*, 1995a, 1996c, d, 1997a; *Berchem et al.*, 1997; *Raeder et al.*, 1996a].

1.5 Simulation runs with fixed solar wind conditions

We have continued a series of simulation runs that use fixed solar wind plasma and IMF parameters. These runs with idealized solar wind conditions will form a data base that we will use to develop our tail magnetopause model. Currently, these runs cover common solar wind conditions (5 nT IMF in various directions, 0.7, 2.2, and 7.1 nPa dynamic pressure, 5.4, 8.7, and 12.8 magnetosonic Mach number) and two dipole orientations.

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Administrative Matters

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Patents or Inventions Resulting

None.